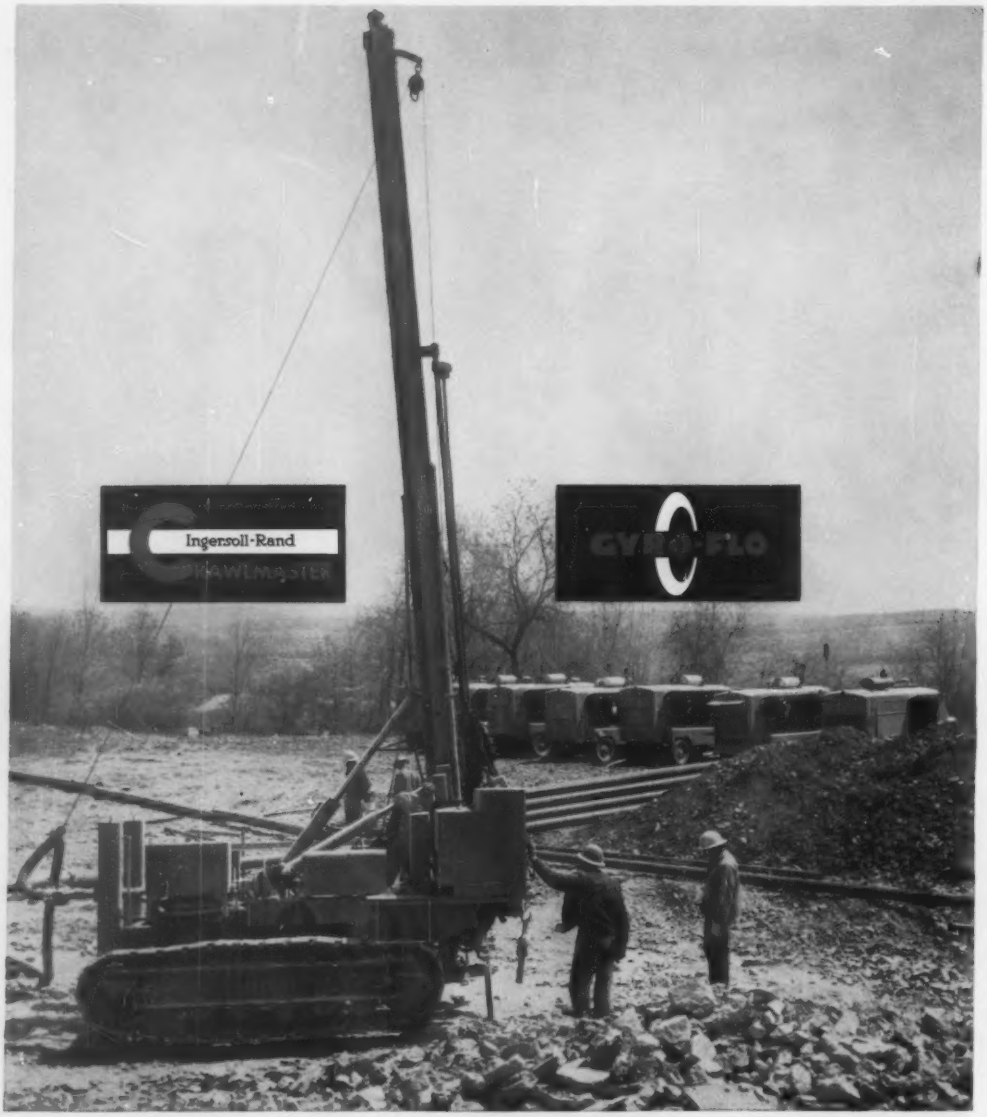
THE EXPLOSIVES ENGINEER

FORE-RUNNER OF PROGRESS IN
MINING-QUARRYING & CONSTRUCTION

NOVEMBER-DECEMBER · 1960

VOLUME 38 - NUMBER 6



New drills pack more weight and power than any other machine in their class

E. J. Petrillo's Yonkers Contracting Co.

MOVES JUGTOWN MOUNTAIN

with Gyro-Flo powered Crawlmaster drills

Three new Ingersoll-Rand Crawlmaster drills are doing the lions' share of the heavy blast-hole work in the 3¼ million yard cut in granite gneiss through Jugtown Mountain near Phillipsburg, N. J. Purchased after competitive tests, the rugged Crawlmasters with constant-pressure hydraulic feed are putting down 4½" holes 18 to 20 feet deep. Using the new D-525 drifter with 5¼" bore, they easily out-drilled two 5½" bore machines. Capable of percussion, rotary or Downhole drilling of 4" to 6½" holes at any angle from vertical to horizontal, the Crawlmaster is by far the most rugged and versatile machine in its class. Supplementary drilling on steep slopes on this job is done by six Crawl-IR drills.

All air power for the Jugtown project is supplied by 900-cfm and 600-cfm Gyro-Flo portable compressors.

The I-R Gyro-Flo line, available in six sizes from 85 to 900-cfm, offers the highest economy in portable compressor history. Outstanding dependability, freedom from maintenance, smaller and lighter, low oil consumption, closer regulation at all loads—these advantages are a matter of record.

Ask your I-R distributor or engineer for complete information on the cost-cutting Crawlmaster Gyro-Flo combination.

Ingersoll-Rand
68A14 11 Broadway, New York 4, N. Y.

A CONSTANT STANDARD OF QUALITY IN EVERYTHING YOU NEED FOR DRILLING ROCK

THE EXPLOSIVES ENGINEER

REG. U.S. PAT. OFF.

Forerunner of Progress in Mining, Quarrying, Construction

When the relocation of U. S. 61 in Minnesota is completed, sportsmen and nature lovers will be able to travel in comfort through an unspoiled area of exquisite beauty, which heretofore had been visited only by the hardiest of adventurers. The new road will make available one of the few remaining primitive areas of the United States.

The building of this highway, originally conceived about 40 years ago, has been so plagued with difficulties in the form of tough geological formations, rugged terrain, and inaccessibility, that several previous attempts to construct it have been abandoned. However, with the latest road-building techniques and the most modern equipment, S. J. Groves & Sons Company of Minneapolis is now conquering these difficulties, and next year this area will be available to tourists.

For a detailed account of one of the most complex geological areas of the world, please turn to page 167 for L. H. Houck's article, "New Northwest Passage."

• • •

The heavy-construction industry is showing much interest in the program for the building of the many ICBM launching sites proposed as part of our national defense program. Some of these ICBM bases are now in the course of construction, and the methods and procedures used and the progress of the work are of particular concern to contractors from a technological point of view.

Starting on page 176 is an article by Farrell Castellani describing the building of ICBM launching systems at Schilling Air Force Base near Salina, Kansas. Mr. Castellani's observations are those of an engineer well experienced in construction and the use of explosives, and should be of interest to contractors contemplating entering this type of heavy construction.

• • •

Sometimes explosives engineers are called upon to do strange and unusual jobs that require not only a knowledge of explosives but also an unusual degree of patience and restraint.

Just such a job fell to the lot of Controlled Demolitions, Inc., when it was called in to assist in the razing of a 100-ft. elevator shaft tower and a seven-story building in a congested area of Baltimore, Maryland. This was part of a clearance program to make room for a proposed civic center. To further complicate an already difficult job the plans for the structures, built many years ago, had been lost, and no one had an accurate idea of the building specifications.

William F. Hallstead tells in his article, starting on page 181, how this demolition job was accomplished with the skillful use of explosives.

• • •

Digging a ditch for a pipe line is really doing a job on the run, for the crew is here today and gone tomorrow.

Down in Texas, just about 35 miles north of the Mexican border, Western Pipe Line Company has dug a 52-mile ditch at a rate that averaged a mile a day—pretty rapid traveling even for a pipe line crew.

Some unusual drilling and blasting procedures were devised for the section of the ditch running through rock, which required blasting. L. F. Hurley, an explosives engineer of wide experience in pipe line ditch excavation, tells about this mile-a-day project. His article starts on page 184.

CONTENTS

CHARLES M. BRINCKERHOFF—*a photograph* 164

CHARLES M. BRINCKERHOFF—*a biography* 165

Editorial 166

New Northwest Passage 167
By L. H. HOUCK

ICBM Base Construction at Schilling Air Force Base 176
By FARRELL CASTELLANI

Controlled Blasting Demolishes Stubborn Buildings 181
By WILLIAM F. HALLSTEAD

Mile-A-Day Pipe Line Ditch 184
By L. F. HURLEY

Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

EDITORIAL STAFF: JAMES J. O'NEILL, *Editor*; THOMAS E. MILLER, *Associate Editor*; GERTRUDE A. DONNELLY, *Associate Editor*; EDWARD L. GRANT, *Art Editor*; HOWARD B. DICKSON, *Production Manager*; A. J. ACKERMAN, *Advertising Manager*; MONTGOMERY R. BUDD, *Director*.

SUBSCRIPTION RATES: *United States and Canada*—One Year, $1.50; Single Copies, $.30; *Limited Subscriptions Only to Other Countries*—One Year, $2.50; Single Copies, $.50.

THE EXPLOSIVES ENGINEER, 670 HERCULES TOWER, WILMINGTON, DELAWARE. PRINTED IN UNITED STATES OF AMERICA.

PUBLISHED BY *HERCULES POWDER COMPANY*

© HERCULES POWDER COMPANY, 1960

VOL. 38 NO. 6 NOVEMBER-DECEMBER, 1960

BPA

GARDNER-DENVER
Since 1859

SEE YOUR GARDNER-DENVER ROCK DRILL SPECIALIST
BEFORE YOU BID YOUR NEXT JOB

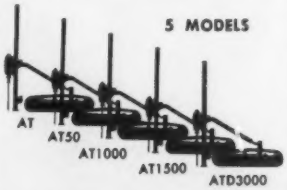
Only Gardner-Denver matches 30 drill-carrier-feed combinations against any hardrock job

You can plan the blast-hole size and depth, the burden and spacing you need for fastest progress. Your Gardner-Denver rock drill specialist will help tailor your rig to meet these conditions. He chooses from the widest selection of crawlers, drills, feeds and accessories in the field.

CRAWLER DRILL

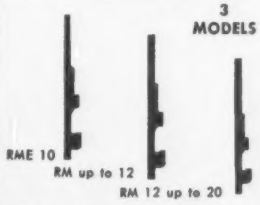
Heavy-duty drill unit for open-pit mining, quarrying and general construction. Uses a broad range of bit sizes with long steel changes.

"AIR TRAC"®



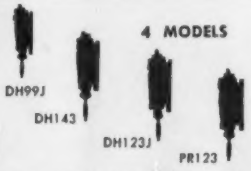
From the basic, low-investment Model AT to the revolutionary swing-boom Model ATD3000 with fully automatic hydraulic power positioning.

CHAIN FEEDS



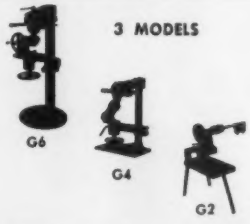
Powered by dependable 5-piston radial air motors with integral gear reducer drives to heavy-duty, rugged feed chains.

ROCK DRILLS



With 3-position steel rotation, for forward, neutral or reverse direction. News-making PR123 also provides rotation without impact, impact without rotation, or impact with rotation—drills up to 30% faster because it uses all hammer energy directly for percussion.

BIT GRINDERS



Sharp bits make hole faster and increase drill steel life. Sharpen bits in the field to save time, have the bit when you need it. A model for any size bit.

DRILL STEEL

HI-LEED* DRILL STEEL
2' to 20' LENGTHS
1¼" AND
1½" HEXAGON

Always uncouples with ease. Snug fit of mating parts increases wear life. Firm connections prevent lost rods.

*T.M.

Complete information in one book. With this booklet and the help of your Gardner-Denver rock drill specialist, you can select the right rig combination to help your next contract reap bigger profits. For your *free* copy, write for Bulletin CDAT-1.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

CHARLES M. BRINCKERHOFF

Charles M. Brinckerhoff

PRESIDENT

THE ANACONDA COMPANY

A Biography

A MAN keenly aware of the social and political changes throughout the world, and the impact these events are having on his employes and their families, is at the helm of The Anaconda Company. Charles M. Brinckerhoff, president of that company since April of 1958, has shown an empathy for his fellow employes, and the townspeople and government leaders around him, which has won for him recognition in several fields of endeavor, not alone in his own company.

In 1925, Columbia University, his alma mater, recognized his qualities of "character, scholarship, and service" when it made him the first recipient of the George Vincent Wendell Medal, and last year by electing him a member of the Engineering Council and of the Columbia College Council. In 1956, the Republic of Chile, where he had worked for many years with Anaconda, recognized these traits in the man when the Minister of Foreign Affairs presented him with the Bernardo O'Higgins Order of Merit with rank of officer, presented to a foreigner who has been of outstanding service to the people of Chile. Born in Minneapolis, Charles Brinckerhoff obtained his early schooling at Elmhurst, Long Island, and graduated from Columbia in 1922 with a B.A. degree, and in 1925 from the Columbia School of Mining as a metallurgical engineer.

Even before he graduated from college, however, he had over a year's experience as a miner, his summer vacations having been spent in Tonopah, Nevada, as a mucker; with the Carson Hill gold mine in California; the Scrub Oak mine near Dover, New Jersey; and the Nichols Copper Company (now Phelps-Dodge) blast furnace in Laurel Hill, Long Island, New York. His first job out of college was at the Phelps-Dodge smelter in Clifton, Arizona, as a testing engineer. The following year he went to Inspiration Copper, owned 28% by Anaconda, as a junior engineer underground. Nine years later he went to the Andes Copper Company, Potrerillos, Chile, as assistant mine superintendent. By 1945 he was general manager of the company, and three years later he became general manager of the Chile Exploration Company at Chuquicamata, Chile, one of the three largest copper mines in the world, if not the largest.

What is the largest copper mine in the world? the mine with the greatest capacity, or the mine with the largest production? Charles Brinckerhoff declines to claim this distinction for Chuquicamata, but in 1959, its year of greatest production, the mine produced almost 613,000,000 pounds of copper. The other possible contender for this "largest" honor, Union Miniere du Haut-Katanga in the Congo, may have greater capacity, but probably did not top Chuquicamata's production record last year because of the difficulties besetting that strife-torn country.

In 1955, Mr. Brinckerhoff was appointed general manager of South American operations; a year later, vice president of the Andes Copper Mining Company and Chile Exploration Company; in 1957 he became executive vice president of the same companies; and in April of 1958, president of the parent company. He is now also a director of most of the Anaconda affiliated and subsidiary companies, as well as of The First National City Bank of New York and of ACF Industries, Inc.

Mr. Brinckerhoff is a member of the American Mining Congress, the Mining Club, the AIME, Mining and Metallurgical Society of America, Pan American Society of the United States, Downtown Athletic Club, the Union Club of Santiago, the Holland Society of New York, Columbia University Club, the Academy of Political Science, a trustee of the Fifth Avenue Presbyterian Church, and of the United States Council of the International Chamber of Commerce, a member of Kappa Chapter of Sigma Xi, the Council of Foreign Relations, and, as previously mentioned, a member of the Columbia Engineering Council and the Columbia College Council.

He lives at 784 Park Avenue, New York City, with Mrs. Brinckerhoff, whom he first met at Barnard, and what more natural place could there be for a Columbia man to look for a wife. They have one daughter, Carol, the wife of Walter Kietzman, assistant mining superintendent at Chuquicamata. Mr. Brinckerhoff's three grandchildren are growing up in the Chilean copper country he and his family have grown to love.

Merry Christmas ★ Happy New Year

Editorial

Beauty in Bridges

The Bureau of Reclamation of the United States Department of the Interior is rightly proud of the designation of the Glen Canyon Bridge as the most beautiful bridge opened to traffic in 1959. The award, made by the American Institute of Steel Construction, goes annually to the bridge with a span of 400 feet or more chosen as the most beautiful design of the year.

Certificates of the award go to the Bureau and to the designer, Robert Sailer, in charge of the Bureau of Reclamation bridge design since 1933. A third certificate went to the contractor, the Pacific-Johnson-Murphy Corporation, for fabrication and erection of the bridge.

We wonder how much leeway a bridge designer has in making his bridge design beautiful. So many other considerations are involved in the construction of such a monumental structure that we feel the designer must have all the problems that the architect for a small house has with his client, and then some.

Yet we are strongly in favor of this means of encouraging beauty of design and feel that it should be extended to other bridge construction. We have always been impressed with the variety and beauty of the small bridges that span the Merritt Parkway in Connecticut. This parkway, one of the earliest limited-access highways built in the United States, has innumerable little concrete and steel bridges spanning the highway to carry the crossroads over the swiftly moving traffic below. Someone with a sense of beauty as well as utility had a hand in their design. Probably few of the millions of drivers and their passengers who speed beneath their arches ever notice the tiny bridges overhead, but they are infinite in their variety of design. What little can be seen from the roadway is not much more than their arches and the railings along the sides, but on these much artistry is evident. Skillful use of iron work has been employed on some; others have concrete railings. Rather pleasing colors have been employed in the maintenance paintings, which other states might well emulate. Let us have more encouragement for bridge design and construction, for too often our highway bridges are little more than elevated roadways without much attempt to make them appealing to the eye.

Mining as a Gamble

The days of the picturesque prospector trudging through desert heat leading a burro past parched cactus plants, or climbing wind-swept icy slopes in search of gold or silver outcroppings, are now almost a thing of the past. The grizzled miner with a stubble of beard and a long, untrimmed mustache is now no more realistic than the popular conception of the cowboy in spurs and silver-decorated chaps riding a prancing pinto pony. The cowboy of today, despite the TV Westerns to the contrary, is much more likely to ride the range in a Jeep or a small panel truck.

So, too, in modern mining the prospecting is much more likely to be done by a seismic crew, or by an aerial photographer, a concept that is as foreign to the popular conception of mine prospecting as is the modern cowboy to cattle raising. With the advances in methods of prospecting for ore bodies some of the gamble has been taken out of mining, and, to this extent, some of the risk attendant upon mining in the past has been removed. The size, depth, location, and richness of the ore body can be determined fairly well in advance of shaft sinking; a better idea of the costs and possible profits from the venture can be obtained before large amounts of capital have been committed to the venture.

Yet with all this, much mining is still a gamble, as is any business run for profit, and the willingness of investors to risk their capital in mining ventures in the hope of producing metal is but little understood by our country. Unfortunately, "penny mining stocks" are almost synonymous with gambling, and the activities of unscrupulous promotors bring discredit to the honestly conceived ventures of the reputable mining companies.

We often lose sight of the fact that most of the U. S. metal production made available today is mined by great mining companies, producing not one but many metals in many mines in this country and overseas. Diversification of their operations, and the consequent spread of the risks involved, has made of these companies stable businesses whose stocks have achieved almost investment status. Plenty of risk is still involved in mining, and the common stocks of the large companies are subject to business vagaries, as are most common stocks, but they are far from the fly-by-night gamble usually associated with "penny mining stocks."

New Northwest Passage

One of the most complex geological formations in the world is encountered in building a highway to a remote Minnesota primeval paradise

L. H. HOUCK*

*400 Linden Drive
Jefferson City, Missouri

UP in the northeastern tip of Minnesota, where the Pigeon River serves as an animated liquid boundary between the United States and Canada, S. J. Groves & Sons Company of Minneapolis has blasted out 7½ miles of new highway in a historic wilderness long known as the most complex geological area in the world.

Beginning 6 miles from the present U. S. 61 and ending abruptly at the deep, swift Pigeon, the new highway, which currently starts nowhere and goes nowhere, will eventually open up scenic beauty on a grand scale in a region steeped in history and teeming with exciting romance of the past.

U. S. 61 from Duluth north to Fort William and Port Arthur in Ontario Province, Canada, follows the shore of Lake Superior until it strikes Reservation River, where it turns inland to cross the Pigeon into Canada at a point 7 miles from its mouth.

The new section of highway, eventually to be a relocation of U. S. 61, taps a well-preserved wilderness by passing near the village of Grand Portage, crossing the Pigeon near its mouth and below High Falls.

Besides the world-wide geological importance of this small corner of Minnesota, this highway will open to the public one of the few spots on the globe where time stood still. Isolated from the iron ranges and agricultural

SIDE CUTS: The rough terrain encountered in the early part of the work presented difficulties when making side cuts. Rock in the foreground shows the excellent fragmentation resulting from blasting.

activity, Grand Portage and its environs have been by-passed by almost all activity since the last of the French voyageurs hung up their canoes and the northwest traffic of the fur traders was blasted by the whistle of the steamboat and the steam locomotive.

But much more than the change in human antics is the fact that because of the massive resistance to erosion by the world's hardest and oldest rocks, the actual physical topography of this particular part of the world has changed little in the last thousand years or so. Not many places like Grand Portage can be found anywhere.

Early History

When the new land route is opened to travel, next year or the following year, some of the vanished glory that was Grand Portage will be restored. The water that splashed over High Falls centuries ago splashes still in the selfsame fashion, as it prepares to become a scenic backdrop for the touring cameraman.

Here at Grand Portage, the first trading post in Minnesota was established in 1679 by the celebrated French explorer, Sieur Duluth. Canoemen of the fur trade paddled up the Great Lakes to Grand Portage long before John Hancock dipped his quill in ink to sign the Declaration of Independence. They found a town of several thousand population, Paris fashions, a flourishing trade, and law enforcement. At one time a garrison of the British Army was stationed here.

They focused on this point because of a protected bay and the necessary "Northwest Passage" by a 9-mile portage uphill to Fort Charlotte, where they could paddle through the chain of lakes and into the Canadian wilderness to trap furs.

The Pigeon River then, as today, was impassable by canoe from the mouth at Grand Portage to Fort Charlotte, 12 miles upstream. In this short crow-flight distance, the river flows 20 miles, often sunk in steep-walled canyons interrupted by falls and rapids.

Grand Portage was the Lake Superior terminus of the Old Grand Portage Trail from Quebec to Montreal. The famed Northwest Company was headquartered at Fort William, 45 miles north. Grand Portage was well established when the United States had no settlements west of the Alleghenies. The spark that was to set off the War of 1812 was yet to be kindled. Here, too, had been a civilization that antedated the native Dakota and Chippewa Indians.

The time of the arrival of the first inhabitants is lost in the mists of antiquity, but remains of their great engineering skill are found today in prehistoric copper mines on Isle Royal in Lake Superior, a few miles east.

Geologists—to say nothing of tour-

FOREST BLAST: This is a typical highway blast. Blasting was preceded by a tough right-of-way clearing job, made arduous by the heavy spruce and birch growth which covered the area.

ROCK REMOVAL: A Northwest 2½-yd. 80D shovel was used to load the blasted rock into 15-yd. Euclid trucks. At right of photograph, in white shirt, is Herb Westphal, project manager for S. J. Groves & Sons Company.

ing "rock hounds"—find here the world's oldest exposed rocks and the most complete sequence of Pre-Cambrian rocks, from the 2-billion-year-old Ely greenstone to the later Keweenawan sedimentary rocks. Here are the granites, the basalt of the lava flows, the Duluth gabbro, the Rove slate, and igneous diabase.

It is readily apparent to the visitor that the isolation of the region, which allowed its preservation in its original state, was not all due to lack of iron ore and pursuit of agricultural activity. It has resisted any of civilization's taming influences. It has always refused to conform. In a sense, since its heyday as queen of the canoe routes and the fur trade, this primeval area has sat up in Minnesota's corner and sulked.

Planned in 1922

This short section of road, completed except for paving by S. J. Groves & Sons, was first planned in 1922. The topography was so rugged, and the proposed route so difficult, that the plan was abandoned as impossible. Later it was placed on the planning boards again with the addition of a proposed tunnel through Mt. Josephine. This plan also was abandoned.

After being a contemplated project for many years, the present route was surveyed in 1932.

A contract for construction of the road was awarded to S. J. Groves & Sons, Minneapolis, for about $2 million, and construction work started October 1, 1958. The contract was completed November 1, 1959. Before the road can be used, a new highway must be constructed from present U. S. 61 to connect with the south end of the new section, and a bridge over the Pigeon River will have to be built. Canada will have to construct a matching road on the other side to effectively take the inland bend out of U. S. 61. Some of this work will be done next year. Eventually new customs buildings for both countries will be built at the new location.

Officially, the section completed by Groves, according to the Minnesota Department of Highways, is Project

LOADING SCRAPERS: Pushing through boggy areas, the loading scrapers handled material so fine that 80% could pass through a 200-mesh screen. The material normally had a 40% water content.

1604-2 (TH 61-1). The project number is given first, and the "TH" in parentheses means "trunk highway"; 61 is the U. S. number; and the extra "1" means that its former designation was Minnesota 1. This is a Federal Aid Primary with the number F001, with official location as 1.5 miles southwest of Grand Portage and Pigeon River. Officially, it was an innocent-looking little job on paper; unofficially, it has been labeled as the roughest, toughest highway job ever completed in the state of Minnesota.

Rank Wilderness

When construction men viewed the surveyed site, it presented a most unattractive appearance for the roadbuilder. This beautiful primeval forest was a rank wilderness overgrown with birch and maple. The topography included some of the highest terrain in the state, characterized by saw-toothed ridges capped with granite and anorthosite, a member of the feldspar family.

The fact that the formations exist gives a clue to their toughness. The mountainous topography is largely the result of resistance to corrosion of the ages by great dikes—tabular masses of igneous rock intruded along fissures and cuts across the beds. There is Hat Point, for instance, a bare diabase rock 400 ft. above lake level, in a ridge that culminates in Mt. Josephine, which rises 1,305 ft. above sea level, or 703 ft. above the water level of Lake Superior.

The route included numerous rock cuts ranging in depth from a few feet to more than 100 ft. and up to 800 ft. long. Some of the road on the northern end as it neared Pigeon River was a lake-shore bog. One of the fills was made in a swamp.

The isolation added to the expense of bringing in heavy-construction machinery. In spite of the historic excellence of the Grand Portage harbor, it was not suitable for lake freighters, and the contractor found that sending in the equipment by water was too expensive.

Here is one place in the world where there is only one way to get there, and that is by U. S. 61, which is connected to Grand Portage and the job site by a narrow, twisting gravel road.

Groves bought two new 80-D Northwest 2½-yd. shovels with Murphy diesels for the job and had them sent to the site in shipping crates. Each made three lowboy trailer loads. While this did not save freight (since such equipment is usually sold f.o.b.) it did save the cost of dismantling equipment in the Minnesota shops and trucking down to the job. The new shovels were erected on the site. The rest of the construction equipment was trucked

or driven to the job from the warehouse yards in Minneapolis.

The ancient connecting gravel road from Mineral Point on U. S. 61 to Grand Portage was worked over somewhat, and regraveled. Shops and offices were set up at the southern end of the site.

When the job was at its peak, a crew of 60 was required. Work schedule was set up at ten hours per day, six days per week, in order to eliminate the need for a permanent labor camp and make it possible for the men to live in the area. Many brought their trailers; others found quarters at Grand Marais, 30 miles south.

Even the clearing of the right-of-way was a formidable job because the birches grew as thick as saw grass. Men with chain saws attacked the larger timber; bulldozers pushed the rest out of the ground and dozed the debris into piles, which were burned.

In round numbers, the excavation quantities were even—500,000 cu. yd. of rock, and 500,000 cu. yd. of earth. Despite the even division of the materials, each represented some of the toughest material ever handled, according to Herb Westphal, project manager.

For instance, the earth excavation was a sooty, black, pastelike material, probably glacial drift, since the area was passed over by five, and maybe six, prehistoric glaciers. Four wheel-type scrapers assigned to this earth excavation met their match. The stuff wouldn't scrape and it wouldn't dump. Some of it had to be handled by the shovels. The rock that had successfully resisted erosion for a few million or billion years was not going to surrender easily to a bunch of modern rock drills in the hands of man.

A test showed that 80% of this material would pass through a 200-mesh screen and that it had a 40% moisture content on dry days, but it rained almost constantly, adding to construction difficulties in a normally short construction season in this locality. These and other problems make the geology of the region of more than average importance.

The right-of-way was surveyed

BLAST-HOLE DRILLS: Four drills, of which three are shown here, were assigned to each shovel. Three air compressors in the background supplied air through aluminum quick-detachable pipe at the right.

across steep slopes, requiring side-cut excavations. Of two typical rock cuts, one was 130 ft. deep and between 700 and 800 ft. long, and the other, the Mt. Josephine cut, was 110 ft. deep and 700 ft. long.

Geology

When they started drilling blast holes into this formation, it was soon learned at first-hand why this area boasted some of the oldest rocks in the world—they were too tough for the elements and probably no construction job ever encountered more interesting geology or a wider range of materials.

This area is in the Laurentian Plateau, also called the Canadian Shield, and is the largest area in the world where Pre-Cambrian, roughly a few billion years old, or what the geologist calls "basement" rocks, lie at the surface. These same rocks are exposed deep in the Grand Canyon, over some parts of Scandinavia, in Australia, in northeastern South America, and in Africa, south of the Sahara.

In the Grand Portage area, which is of so much historical and geological interest, the mountainous ridges, points, and islands owe their existence mainly to massive resistant rocks formed from molten material poured out on the surface or forced into fractures or layers in pre-existing rocks. Erosion by streams and great glaciers that carved out the topography when they occupied the Superior basin left the area in its pristine state, having been only slightly modified by post-glacial erosion, with little doubt that the present contours of the area were developed in preglacial time. This is true of few places in the world.

Rock in the cuts on the southern end and middle sections of the job, such as the Mt. Josephine cut, was largely gabbro and diabase, the two words often mistakenly used interchangeably. Diabase is a dark, heavy, intrusive rock with a composition of basalt or gabbro, but with lath-shaped plagioclase crystals belonging to the feldspar family. Geologically, gabbro is a coarse-grained igneous rock of dark color, consisting mainly of plagioclase, of the feldspar family, and pyroxene, which primarily is magnesium and iron silicate.

The geology of this region should not be reckoned without consideration for Lake Superior, the largest and deepest fresh-water lake in the world, with its surface 602 ft. above sea level and much of its bottom below sea level. This 360-mile-long lake, 160

NEARING COMPLETION: Looking north from the Mt. Josephine cut across the Pigeon River to the Canadian shore in the distance, one can view the primitive beauty of the area.

ROVE SLATE: Part of the right-of-way passed through Rove slate, a formation equivalent to Virginia slate. This is a rock harder than conventional slate and lacking in characteristic slate cleavage.

miles wide, and with a surface area of about 32,000 square miles, is located in the trough of a giant downfold in Pre-Cambrian rocks, with the action having occurred recently by geological time, only 600 million years ago. Most popularly accepted theory of its origin is that it was scooped out by the successive glaciers, that its forming was one of the last great geological events in the region, occurring during the final stage of extensive volcanic activity.

The Duluth gabbro intrusion, a famous mass of igneous rock, underlies much of the north shore, and formed much of the structure of the rock-excavation portion of the Groves job. It resulted from successive lava flows, piled one on top of another until they reached a thickness of more than 30,000 ft., or 6 miles. These flows are supposed to have come out under pressure from the earth's center, not from puny volcanic eruption, but from a giant crack in the earth's crust.

While the geological background gives an idea of some of the problems of roadbuilding in this area, there was still another problem of the rock formations. The area is also noted for its exposures of Puckwunge conglomerate, which was created by the sudden outpourings of basalt and felsite lava flows which halted the deposition of sand in spotty areas.

Then on the lower middle of the job, there was a vast formation of Rove slate, a formation equivalent to Virginia slate, which was formed by mud, pressure, and time eons ago. This slate is a hard rock, harder than conventional slate and also lacking in characteristic cleavage, although parts of the formations followed conventional cleavage rules.

The worst part of the whole business of encountering the widest range of formations in the world is the difficulty in determining the reaction and results of blasting in advance, as well as the difficulty in prejudging drill footage.

Two Excavating Teams

But with all the questionable factors, Herb Westphal, project manager, arrayed a formidable drilling setup

against the massive resistance of the formations.

He divided it up into two teams, each headed by one of the new 80-D 2½-yd. Northwest shovels. To each shovel he assigned four Air-Trac Gardner-Denver D-123 drills; 3-in. detachable bits were used on the drill stems. These drills received their air from three 600-f.p.m. Ingersoll-Rand Gyro-Flo compressors with GM 6-110 diesel engines.

Three-inch blast holes were drilled in a 7 by 7-ft. pattern, all to 20-ft. depths, using two 10-ft. lengths of carburized sectional and Timken detachable bits. Because of the formation, blast hole drilling became a major portion of construction cost. But good management helped reduce this cost by the use of light aluminum 4-in. air distribution pipe, with quick-coupled, wrenchless type of connections for the 20-ft. 22-lb. sections.

Westphal had an air hose valve placed at each connection. Air compressors were often perched on top of cuts with air lines running down the sides. This maneuver saved almost all of the usual expense of moving compressors out of blast areas. The valve at each 20-ft. coupling made it possible to hook up drill lines at any spot that proved convenient.

20-ft. Benches

Using the same depths, and shooting out the cuts in 20-ft. benches proved economical too, since it was geared to shovels and loading. Once the sequence had been perfected it allowed the job to speed along to take advantage of the good days and the short construction season.

Another refinement of the method eliminated all secondary blasting and delivered banks "shot" to the proper angle, which required only minimum scaling for acceptance. This was accomplished by drilling the back row of holes at the required ¼-to-1 angle, as compared with the regular holes, which were drilled vertically.

The back row holes were drilled on 3½-ft. centers, and by using 0 to 8 period delay electric blasting caps, the blasts cut the slopes precisely on the

MT. JOSEPHINE CUT: This cut, 110 ft. deep, shows the slope which resulted from blasting at an angle. In the center of the photo is one of the many volcanic dikes found in the formation of Duluth gabbro.

required angle. Westphal said that on some blasts the cleavage between the rest of the blast and the back row was such that the movement of the material by the angle shots could be seen with the naked eye.

The amount of time saved, as compared with the usual methods of dressing slopes to grade, using crews with jackhammers and the crews ordinarily assigned to boulder popping, soon added up to substantial savings.

Blast holes were loaded with 2 by 16-in. cartridges of Gelamite® 1, with an average of 30 lb. used per hole. In some cases a small amount of Dynatex®-B, a nitro carbo nitrate blasting agent, was used, along with the Gelamite 1; but most of the holes were wet, making the use of dynamite more economical.

Loading the angled blast holes on the back row was considerably more difficult. Because of the angle, less explosives were needed in the lower half, as there was a smaller amount of material between it and the adjoining row of vertical holes. More explosives were required at the top of the holes because of a greater burden. A proper loading formula was soon arrived at so that the blasts, for the most part, accomplished the purpose of delivering a properly angled bank.

Relatively large blasts were the rule, with 300 to 700 holes being detonated at a time, using a condenser discharge blasting machine with a capacity of 1,200 caps. The average blast produced 1 cu. yd. of rock for each pound of dynamite; thus, each blast delivered between 9,000 and 25,000 cu. yd. of well-blasted rock.

The fragmentation resulting from the loading was found to be ideal for the 2¼-yd. dippers of the Northwest shovels, and no large boulders were left for secondary blasting.

The shovels loaded into a fleet of eight 15-yd. end-dump Euclids, with mixed engines, Cummins and GM diesels. The trucks dumped in the fill areas in the center, rather than directly at the end, which, as Herb Westphal explained, made it possible to compact with the normal operation of the haul rigs and the tracks of the dozers used for spreading. This method of dumping gave the material a chance to spread, had the effect of pushing the larger rocks down and conserving the natural fines for choking the crevices. The resulting fill was compacted to specifications, with tests showing no voids without rolling. Compaction of the earth areas was by sheep's-foot rollers. Dumped loads were spread by a fleet of six Caterpillar D8's with dozers and straight transmissions.

DEEP FILL: Along the route of the highway many deep fills were required. This one is over 100 ft. deep; fortunately, the excavated material almost equaled fill requirements.

Fortunately, the excavation material almost equaled the fills and only a small amount of borrow was required; this was obtained near the Pigeon River end of the job and consisted of pit-run sand and gravel.

The subgrade was 54 ft. wide; some of the fills required on the project were more than 100 ft. deep; and one rock fill was over a muskeg swamp.

Project Personnel

Personnel supervising this interesting job included Lester H. Miller, district engineer for the Minnesota Department of Highways, and John Youngquist and William Highmark, highway department project engineers.

For S. J. Groves & Sons, Herb Westphal was project manager and Elroy Dragsten, project engineer; Ray H. Mills, Bill Sullivan, Milton Atherton, general foremen; Leo Ashmore, grading foreman; John J. Cathers, powder foreman; Reinhold Sorenson, drill foreman; and Ernie Deadrick, master mechanic.

ICBM Base Construction At Schilling Air Force Base

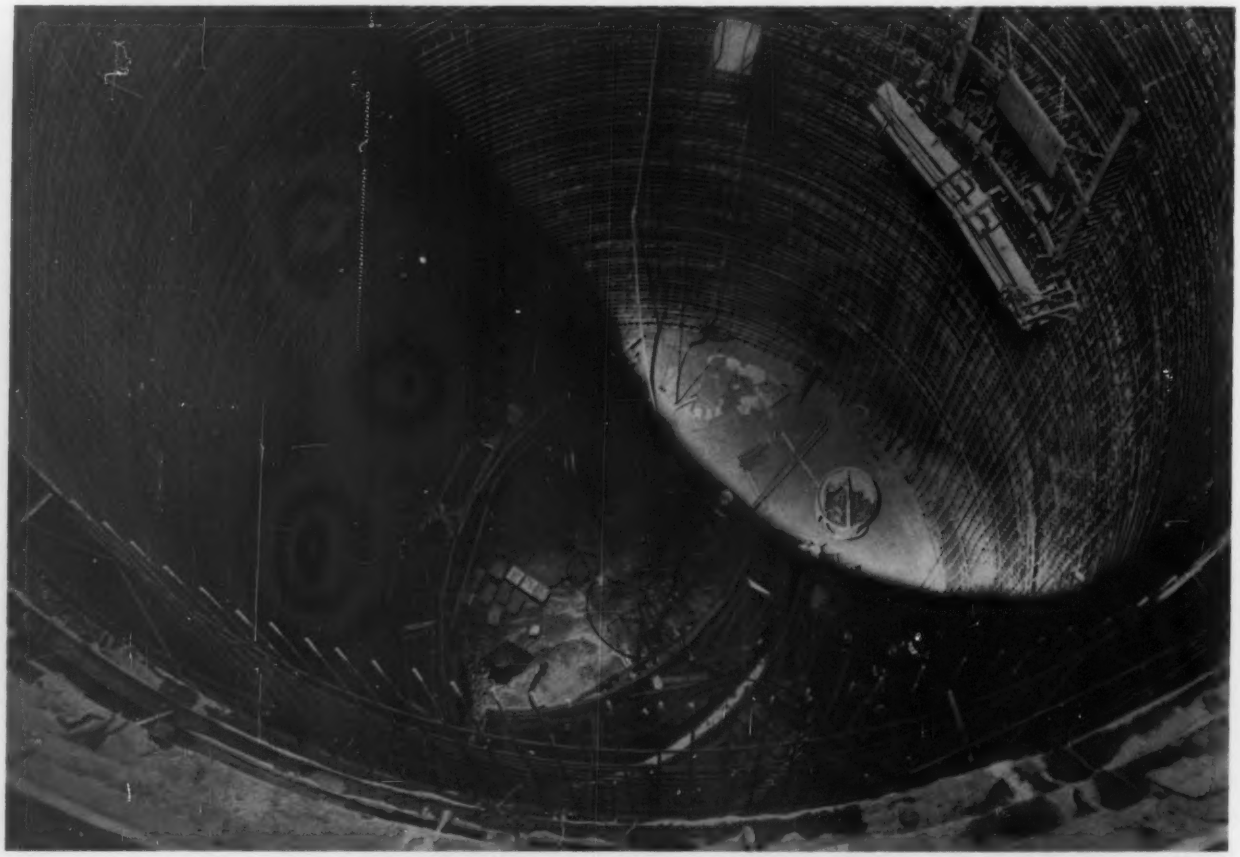
The first of a series of ICBM launching sites, an important part of our national defense, is rapidly nearing completion at Salina, Kansas

FARRELL CASTELLANI*

CAPE CANAVERAL in Florida, Vandenberg Air Force Base in California, and other testing laboratories for missile-to-ground targets and to outer space, along with other testing sites, are the centers of much of the construction work going on in this country. These bases and testing-site bases, as they have grown in size and importance, have become direction finders for work in the construction field, involving billions of dollars required to expand facilities surrounding heavily populated areas and military installations.

Nike, assigned to the Army, and the Atlas, Titan, and other missile-base sites assigned to the Strategic Air Command are in various stages of con-

*Hercules Powder Company
Joplin, Missouri



LOOKING DOWN: Shown here is the shaft for housing the Atlas missile at the ICBM base at Salina, Kansas.

struction in all parts of the country.

The first operational long-range missile in SAC is the Atlas. It is 82.5 ft. high, 10 ft. in diameter, and weighs 260,000 lb. It is known to have a range of over 6,000 miles. The power plant consists of two booster rockets, one sustainer, and two small vernier rockets. In the operation of the Atlas Intercontinental Ballistic Missile, the boosters are jettisoned first and the verniers are used to trim the velocity. The maximum thrust developed at take-off is in excess of 350,000 lb.; the power of over 17,000 automobile engines is incorporated in the missile power plants described here, exclusive of the warhead involved.

Three Launching Systems

Three systems are employed in launching these giant missiles: one launches the missiles from reinforced concrete pads; the second stores the missiles horizontally in huge concrete boxes, with accompanying facilities able to move the missiles into vertical firing position quickly; the third and latest method stores the missiles in underground silos, or shafts, in a vertical position, ready at all times for quick use. The Atlas Intercontinental Ballistic Missile site at Schilling Air Force Base, Salina, Kansas, one of the last-mentioned systems, is now under construction; several more will follow immediately in the Midwest.

On March 4, 1960, the Kansas City District Army Engineers received bids for construction of nine ICBM silos. The successful bidders, a joint venture of Utah-Manhattan-Sundt Construction Company of California, Oklahoma, and Arizona, bid $17,209,000. The contract specified completion in 13 months. The contract was later increased to include 12 silos. The Army Engineers negotiated a contract for the three additional silos for $6,174,000 in June. The contract with the Utah-Manhattan-Sundt Construction Company involves the excavation and finishing of the silos with heating and air conditioning, along with excavation for roads and other facilities. The construction at each location requires

DRILLING MACHINE: It was necessary to raise the drill from the floor of the shaft before each blast was fired. Here it is being returned to the shaft floor following a blast.

the excavation for a shaft 60 ft. in diameter and 179 ft. deep. The shaft proper is 140 ft. deep, with the top 39 ft. excavated over a considerable area to accommodate personnel. The shafts are steel reinforced, finished in concrete, and designed to house the Atlas missile, equipment, and fuel for propulsion of the missile. These silos are said to be one-shot affairs. Schilling Air Force Base is the first of the so-called hard Atlas missile bases, with others to be built, or now being built, in Kansas, Nebraska, South Dakota, Oklahoma, Texas, and New York. The power packed in the warhead of one of these missiles is reported to be more than the power of all bombs dropped by all countries in all of World War II.

First Phase to 39-ft. Depth

The first phase of the contract held by Utah-Manhattan-Sundt involves the excavation at the shaft site to a depth of 39 ft., and other excavation such as roadways. This work was sublet to the George Bennett Construction Co., Bethel, Kansas, and provides for about 850,000 cu. yd. of excavation at 12 sites in an area of something like 5,000 sq. mi. The material excavated is hauled to spoil banks and all will be used to fill around the completed structure to a height of approximately 7 ft. higher than the original ground line, with nothing visible after construction is completed. The contractor on this phase of construction used DW 20's, DW 21's, DW 10 Cat scrapers, and D 8's. No shovel was used in this excavation and no drilling or blasting was required. The largest individual contract sublet by the prime contractor was awarded to the Walt Keeler Co. of Wichita, Kansas, for concrete work. Mr. Keeler will set up mixing plants at each of the sites to take care of the large amount of concrete required.

The material encountered in the sinking of the shafts varies so much that no set procedure could be established, the deciding factors being the hardness of the material and the amount of water present, since the sites ranged from very dry to very wet. Materials encountered below the 39-ft. level were soft, medium hard, and hard clays; sand, sandstone, cemented sandstone; soft, medium, and hard shales; gypsum; and limestones.

The hardness of the material met in the shaft-sinking operation dictates the method of handling. Front-end loaders are placed in the shaft and soft material is loaded onto 4-cu. yd.-capacity buckets which, in turn, are

MUCKING: Cleanup on the shaft floor was accomplished by a front-end loader dumping the muck into a bucket.

hoisted out of the shaft by crane and dumped into 10-cu. yd.-capacity trucks for hauling to the spoil area. The front-end loaders are equipped with rooters to loosen the material too hard to handle with the loaders alone. Material too hard to dig or root is drilled and blasted and then loaded by the front-end loaders. While the makes and models of equipment used in the shaft-sinking operations vary, with the pattern of procedure being adapted to each site, the performance of the same duty by different makes of equipment at each different site is uniformly good throughout.

Seven Shafts Sunk

This joint venture observes a 168-hr. work week. Seven shafts were being sunk simultaneously at the peak of sinking operations, and much of the work was dry. In one of the shafts water was encountered, with as much as 1,500 gallons per minute having to be disposed of. This presented a serious problem, and several methods were tried to handle the situation. First, nine holes were drilled around the perimeter of the silo, and deep well pumps were installed. Numerous well points were installed in holes drilled from within the silo. Weep pipes were placed at effective locations and water collection rings were constructed. At the silo bottom, a sump was maintained well below the sinking operation. All these together controlled the ground water and allowed the silo excavation to proceed normally.

At another site, grout was employed to seal off the ground water. This grout curtain, though not 100% effective at all horizons, did cut down the flow of water materially and permitted the work to advance.

The shaft proper has ring beams on 4-ft. centers installed as the shaft is being sunk, and the water problem at one of the shafts was solved by placing corrugated metal sheets between the ring beams and the shaft face, and placing a bleeder pipe at a convenient point and a pump attached to force the water out of the shaft. The shaft face is gunite protected, and 2 by 2-in. wire mesh is placed against the gunite. The concrete wall in the shaft will be 2 ft. 6 in. thick at the base, increasing

to several feet more in thickness near the top of the shaft.

Loaders Protected from Blast

Equipment used in the shaft excavation consists of a Link-Belt 108 truck-mounted crane. The crane, at shallow shaft depth, picks up the loosened shaft material with a clamshell bucket to dump onto 10-cu. yd. Koehring Dumptor, LeTourneau D pull, or GMC trucks. As the depth of the shaft progresses, two 4-cu. yd.-capacity round buckets are used, and the crane hoists and dumps these buckets alternately onto trucks after they are loaded by loaders in the shaft. Lorain cranes also are in evidence on this work. The front-end loaders in the shaft, Allis-Chalmers HD 11 or Cat 977 Traxcavators, are all equipped with rooters. The loading machines are left in the shaft throughout the operation. When a blast is fired, a ½-in. sheet of metal is placed on the loader for protection. The generally light blasting required in the material encountered in this work lessened the chance of damage to the loaders.

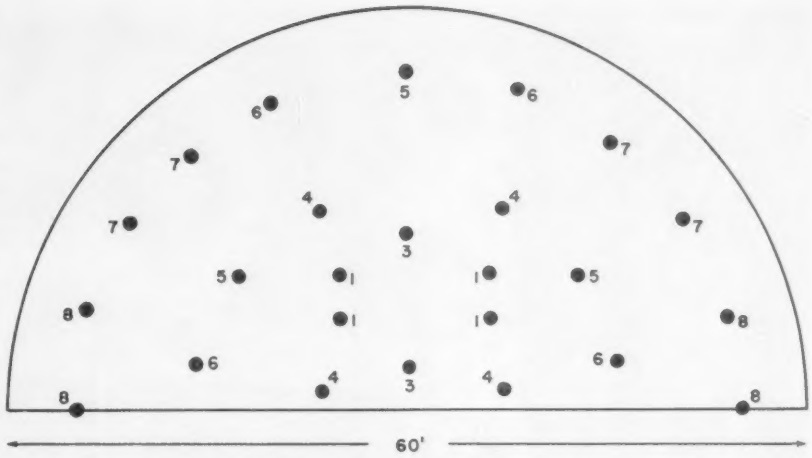
The drilling equipment, Ingersoll-Rand crawler drill machines, is hoisted out of the shaft prior to setting off each blast. Air is furnished at each site away from the shaft by 600- and 365-c.f.m. Ingersoll-Rand machines, with metal pipe laid underground to the collar of the shaft, enabling hose connections from these to the drill.

An interesting bit of excavation in the shaft-sinking operation is a sight line running from 100 ft. down the shaft to the surface at a 49° angle and 9 in. in diameter. The sight line is dug man-size to accommodate a 9-in. pipe, and digging operations go forward from top and bottom.

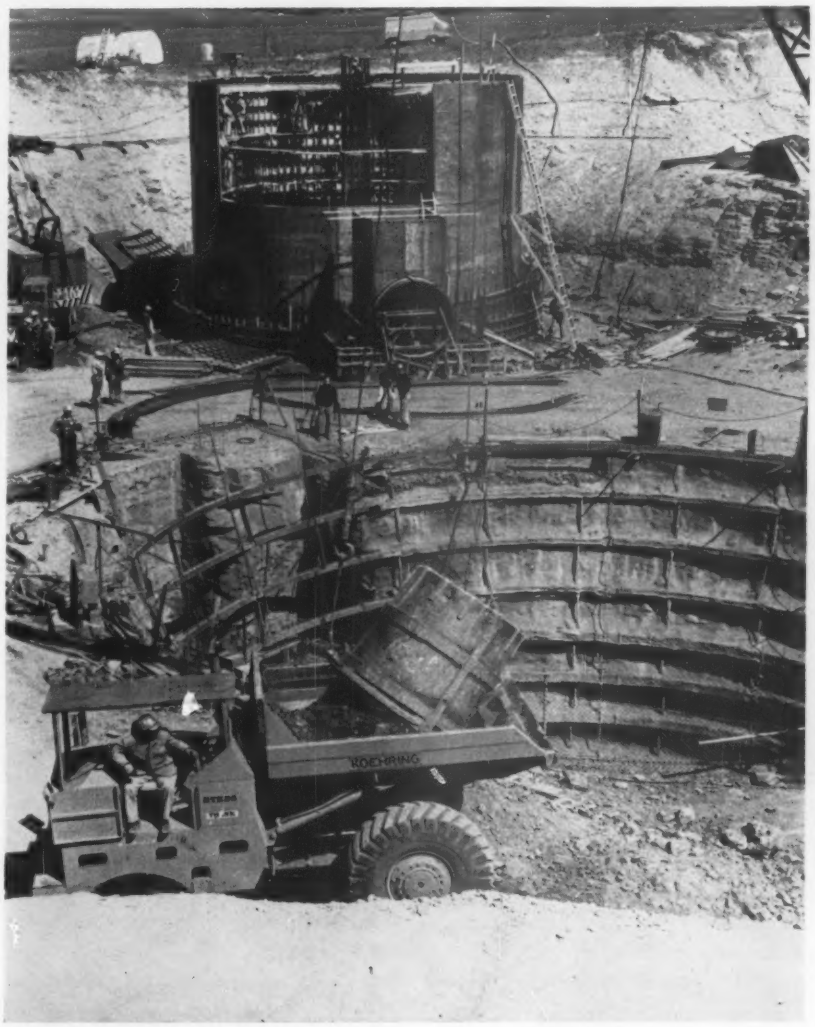
Each shaft has a wire mesh sheet across its center down to the bottom for the safety of the workers.

Half of Floor Blasted at One Time

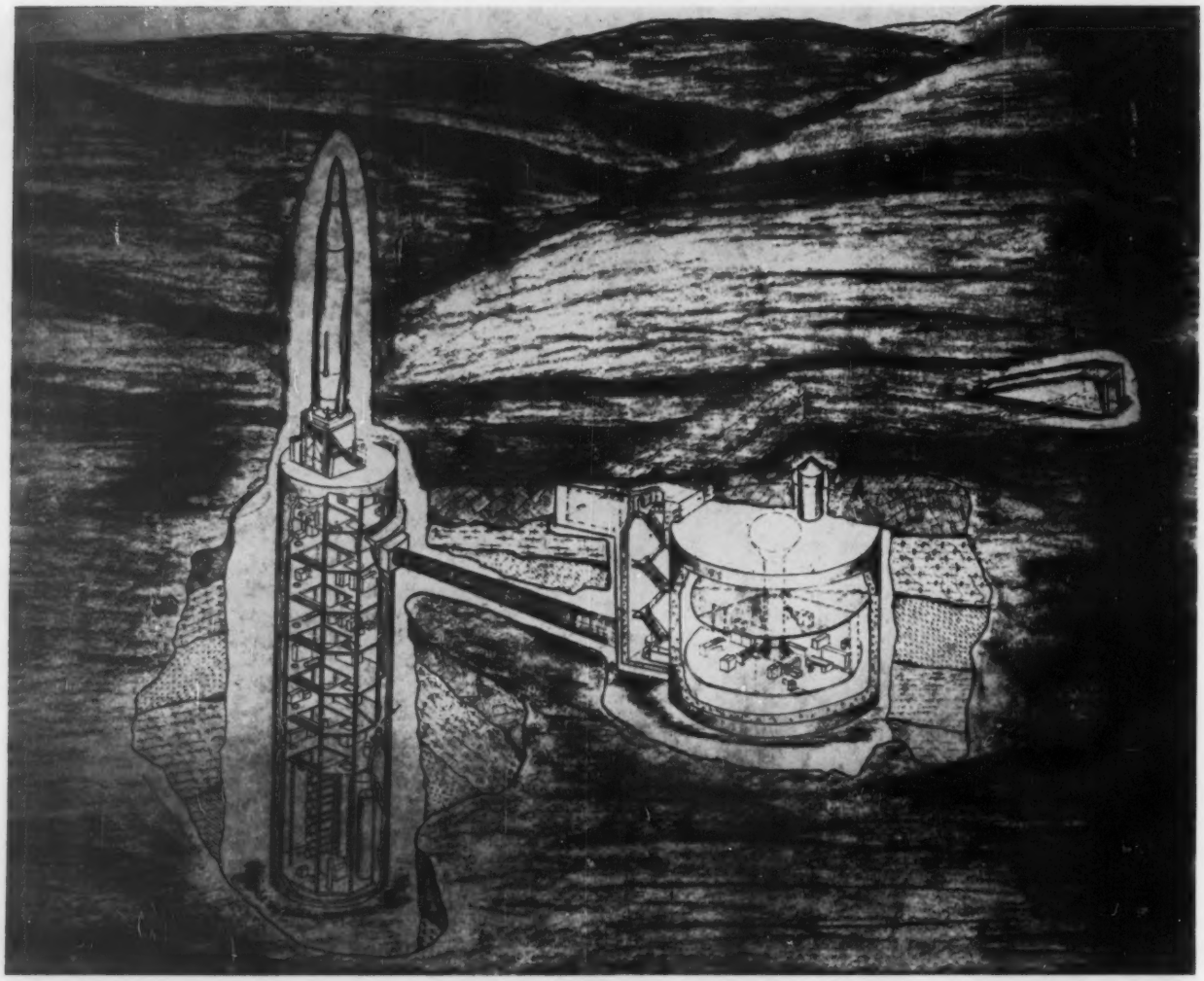
The drilling and blasting operation is varied because of the types of material encountered, but generally one-half of the shaft floor is blasted at one



BLASTING DIAGRAM: Generally, a blast covered one-half the shaft. Numbers beside the holes indicate the delay period used. Four cut holes in the center, marked for first delay, sometimes are fired by instantaneous electric blasting caps.



MUCK DISPOSAL: After lifting the muck from the shaft, the crane dumped the contents of the muck bucket into a truck, which hauled the excavated material to a spoil bank.



ARTIST'S SKETCH: The missile in firing position is shown in this sketch of the completed underground silo. Also shown are the control center and other necessary facilities.

time. One procedure used was a 24-hole round in the 60-ft.-diameter shaft. This was in medium shale, with holes started 2 ft. from the shaft perimeter line. After blasting, the 2 ft. is spaded to the shaft wall grade line. This avoids overexcavation or overbreakage on blasting, and in softer material the holes are started as far as 5 ft. from the shaft perimeter.

Ten or 11 holes 10 ft. deep are drilled along the perimeter of one-half the shaft floor. Six 10-ft.-deep holes are drilled 8 ft. from the first, or near-perimeter, line of holes. Inside this pattern are four cut holes and four reliever holes to complete the round. Four cartridges of Hercules® 40% Extra Gelatin, 2 by 8 in., are used in each of the 2¼-in.-diameter holes. The load factor on explosives varies from 0.2 lb. per cu. yd. to 1 lb. per cu. yd., depending on the hardness of the material. Short-period delay electric blasting caps are used, including instantaneous to No. 8 short-period delays. The method of delaying in each half-shaft round depends on whether the blast is the first at that particular level. If the blast is the first one at each level, faster delays are used along the center line of the blast. If the blast to be fired is the second, slower delays are used along the center-line holes to minimize throw from loose muck or a free face opposite the center-line holes. The diagram shows a typical shot. A CD 48 Condenser blasting machine is used to fire a round from the top of the shaft. The only equipment left on the shaft floor at the time of firing is the front-end loader. All other equipment is moved out. The ring beams installed in the shaft act as sentinels, reminding the men to exercise care and caution in blasting procedure, because a misdirected shot can and does bend one of the beams occasionally.

Jim Stewart is project manager for Utah-Manhattan-Sundt Company; Cecil Welton is assistant; N. K. Robbins is shaft superintendent; J. D. Davenport is shaft engineer. Col. J. M. Leonard is the Army Area Engineer at Schilling Air Force Base; Col. E. L. Little is representing the Air Force Ballistic Missile Division.

Controlled Blasting Demolishes Stubborn Buildings

Despite a congested area, precision blasting safely removes buildings to make way for a new civic center in Baltimore, Maryland

WILLIAM F. HALLSTEAD*

CALM PERSEVERANCE, good judgment, and controlled blasting recently brought success to John D. Loizeaux, president, Controlled Demolition, Inc., when the odds seemed to be mounting high against him. The very nature of his work—dynamite demolition in crowded urban areas—preordains difficulties that seldom occur to the explosives engineer who handles normal blasting. First, Loizeaux faces the problem of selling the efficiency and safety of his operating procedure to ofttimes reluctant officials. Then he must perform before a tough audience of these very same men. This is what Jack Loizeaux is up against before the building comes tumbling down.

Further complicating the demolition of a 100-ft. elevator shaft and a seven-story building on the site of Baltimore's future Civic Center was the situation so often evident in this kind of work: original plans for the old structures had been lost years ago and no one had an accurate idea of the building's original specifications.

The Civic Center will occupy the entire first block of Hopkins Place in downtown Baltimore, Maryland. By midsummer of 1960, standard balling procedure had cleared the area of its densely packed old buildings with the

DOWN SHE GOES: Because of the unknown construction of the elevator tower, one of the buildings to be razed, four blasts were required to topple the stubborn structure.

*517 Wyngate Road
Lutherville, Maryland

STEEL SUPPORTS: The Miller Building, the other stubborn structure, failed to fall after the first blast, and an examination of the blasted areas revealed extensive steel-reinforced supports.

exception of a highly resistant elevator shaft—100 ft. in height—topped with two big wooden cooling tanks, and the seven-story Miller Building. The leveling of these structures was left to the blasting contractor, both to shorten working time and because of the difficulties encountered in previous attempts to ball them down.

A Difficult Blast

Loizeaux selected a holiday as the best date to dynamite the structures. He reasoned there would be very little traffic—vehicular or pedestrian—in the central city on a holiday. Spectator control is always a major problem in this type of work. Because the two structures were clear on all four sides, Loizeaux decided to bring them down together. Through the weekend preceding the blast, the two structures were drilled and loaded with approximately 150 lb. of 60% high-velocity gelatin. The explosive was placed in 1½-in. bore holes drilled with a Gardner-Denver rock drill, mainly in the basement columns of the Miller Building, and primed with a series of millisecond delays.

The blast was fired at 7 a.m. before a group of police, fire, and other city officials, plus a gathering of spectators much larger than had been anticipated. Rumors of the impending blast had been heard by the newspapers, and the resultant publicity caused a large throng of spectators to assemble.

When the dust of the first blast cleared, the two structures still stood. A check of the building revealed that steel reinforcing in the basement columns had been far more extensive than originally estimated. The concrete had been blasted away, but now the building was literally resting on the bare steel!

The reason for the tower's failure to collapse was more subtle, and it was not to be discovered for some hours. Loizeaux elected to postpone further work on the building and to concentrate on the tower. At noon and again at 2 p.m., two additional blasts were fired in the tower base, with no apparent results. By this time, of course, local radio stations were publicizing the stubborn tower that refused to die.

The blasting contractor could have brought the tower down by heavily overloading the base, but this would have created a hazard from possible

flying debris. The only acceptable technique for urban dynamite demolition in congested areas calls for maximum effect with minimum explosive charges, no matter how tedious the demolition process may become in the case of balky structures.

Double-Thick Wall

Following the third shot, Loizeaux made a series of measurements of the tower base and discovered that one of the exterior walls was actually double—the adjacent interior wall being a solid 10 in. thick, and thus far had not even been touched by the three preceding shots. The crew drilled through the outer wall, and placed 3 lb. of explosive in the hitherto completely concealed interior face.

This proved to be the key. At 7 p.m., the fourth shot was initiated and the tower collapsed neatly to the south.

A week later the Miller Building was attacked, and the technique was quite unusual. The first firing had knocked out much of the north wall along with the concrete of the supporting columns. The demolition firm shored up this wall with heavy timbering and went to work on the steel reinforcing that remained of the supporting columns. The bars were cut with torches, and that action slowly transferred the building's main weight to the timbering and an adjacent brick wall.

The timbers and adjacent portions of the building, including the brick wall, were loaded with 115 lb. of 60% gelatin, millisecond-delayed in 137 holes. At 7 a.m. the blast was fired. The entire Miller Building collapsed within 27 seconds after initiation of the explosive, and, as one Baltimore newspaper put it, "with an almost gentle rumbling as the concrete and brick crumbled."

BEGINNING TO MOVE: As the supporting timbers are blasted out by small dynamite charges, the seven-story Miller Building in downtown Baltimore leans to the left, as shown in this photo.

REALLY MOVING NOW: Gravity is now at work, and the building breaks apart as it falls onto a cleared area, exactly as planned by the blasting contractor, who used an unusual technique.

SUCCESS CLOUDS: The clouds around the base of the now almost demolished building are from crumbling masonry. The building collapsed within 27 seconds after initiation of the dynamite.

THE END: A neat pile of debris is all that remains of the Miller Building after dynamite had done its work. Portions of the still standing wall are of another building being balled down.

Mile-A-Day Pipe Line Ditch

Western Pipe Line Company uses cap-and-fuse method of initiation in blasting Texas limestone for a 20-in. pipe line

L. F. HURLEY*

DIGGING a 52-mile ditch just north of the Mexican border can be a hot and grueling task. Western Pipe Line Company of Austin, Texas, undertook such a project for El Paso Natural Gas Company to bring in gas from the Brown and Bassett field, located north of Dryden in Terrell County, Texas, which connects with El Paso's main line running through the Puckett field.

The route lay through hot, scrubby, mesquite-dotted mesa 35 miles north of the border. The right-of-way, which averaged 2,300 ft. above sea level, crossed the canyon through which Independence Creek runs seven times. In spite of these difficulties, the pipe line crew managed to push the ditch for the line over the desert at a rate which approached a mile a day.

*Hercules Powder Company
Joplin, Missouri

The Brown and Bassett field, 30 miles north of Dryden, was discovered by the Magnolia Petroleum Company almost three years ago. Ten wells already in the field average 80,000,000 to 100,000,000 cu. ft. of gas a day. The gas is contaminated with 45% carbon dioxide, which will be removed by the El Paso Natural Gas Company in a plant now being built at the field. The new line consists of 52 miles of 20-in. pipe, and an 8-mile gathering system which runs from 8 to 24-in. pipe.

At the peak of operations Western Pipe Line had 200 men on the job, working first out of the company's offices in Fort Stockton, and later, when the halfway mark had been passed, out of Sanderson, Texas. Each crew, carrying plenty of ice to the job, was paid riding time one way, and worked 10 to 12-hour shifts.

Rock Country

Construction started at the Puckett field end of the line, approximately 25 miles southeast of Fort Stockton. The first 10 miles ran through high rock country locally referred to as

QUAD DRILLS: Two sets of quads drill both sides of the ditch at once. Each is a Gardner-Denver 99D cradled by Allis-Chalmers HD 16 side-boom tractor, and driven by two Gardner-Denver 600-c.f.m. rotary compressors mounted on Athey trailers.

MAKING UP PRIMERS: Two men were assigned full time to making up primers. The cartridge was primed with a regular blasting cap and 8 ft. 2 in. of Ensign-Bickford's Clover orange fuse. The cap-and-fuse method of firing provided delay effect in the shots.

LOADING: Six cartridges of Hercol 2, 1½ by 8 in., were loaded in each hole, and the third cartridge from the bottom was primed with a Hercules Regular Blasting Cap. Ditch Foreman Bill Beaver, with hat, watches the loading procedure.

mesa, then dropped off into Independence Creek Canyon for a distance of approximately 35 miles, finally climbing back up the mesa and into solid rock for the last 5 miles.

Work began on May 15, 1960, under a contract requiring Western, before drilling, to attempt to rip rock with equipment having not less than 230-drawbar horsepower and using a Kelly-type, or similar, ripper. Work on the line began with five Caterpillar D8 and D7 angle dozers clearing the right-of-way. A D9 Caterpillar, pulling a Kelly ripper where possible, was used; this was followed by two Cleveland 320 ditchers.

While some sheep men would contend that nothing would bother a sheep in lambing season, nevertheless, in the interest of good neighbor relations, El Paso aske the contractor to restrict all blasts to delayed shots. For this and other reasons Western Pipe Line used cap and fuse for blasting.

When blasting was necessary, Western used two quad drills and two twin drills. Two Gardner-Denver 99D quad drills on side booms had air supplied by two Gardner-Denver 600-cu. ft. rotary compressors mounted on Athey trailers to each set of quad drills. One Gardner-Denver 600-cu. ft. rotary compressor similarly mounted furnished power for each of the twin drills. The drills were carried by Caterpillar D7 tractors and Allis-Chalmers HD 16 tractors, both with side booms. Timken carbide insert detachable 2-in.-diameter bits and 1½-in. drill steel were used for this work.

Drilling and Blasting

Two rows of holes were drilled 32 in. apart. The holes in each row were spaced 48 in. apart on a staggered pattern to a depth of 68 in., which was 18 in. below grade. The ditch width of 32 in. allowed 6 in. on each side of the 20-in. pipe for padding. Western put in 30 in. of cover, when the line ran through soil, and 24-in. cover in rock. Six inches of padding was placed top, bottom, and at the sides of the pipe.

The usual loading procedure provided for six cartridges of Hercol® 2 1½ by 8-in. cartridges to a hole. Two cartridges were placed in the bottom of the hole and tamped. A primer cartridge then was primed with a Hercules® Regular Blasting Cap crimped to 8 ft. 2 in. of Clover* orange wax fuse which was supplied in 100-ft. coils. The primer cartridge was tamped lightly in place, and then three additional cartridges were tamped in the hole. The remaining 12 to 24 in. of collar was filled with soil and tamped. Holes loaded with six Hercol 2 1½ by 8-in. cartridges would provide 3.5 lb. of explosive in each hole. The loading plan used resulted in an average explosives loading ratio of 1½ lb. to the linear foot of ditch blasted.

The drills put down from 160 to 175 holes for one shot. One man provided with three 12-in. lighters would ignite the fuses, which were curled and split with notches into which the lighter was touched. This gave him about 6 minutes to complete the lighting. Often the first holes would begin to go as the last fuses were lighted, but by this time the workman would be over 600 ft. away at the other end of the string of holes and could complete the lighting and clear out before the shot had progressed very far down the line.

When hills were encountered, Western arranged the blasts so that they would break down by lighting the fuse from the bottom to the top of the hill. This was also safer. When the holes were lighted from the bottom up, the powder man would be at the top of the hill when the hole started to fire at the bottom, rather than at the bottom, where holes firing at the top might easily throw rock down on him. Excellent breakage was obtained with the cap and fuse, and very little back shooting was necessary with this procedure, whether on hills or on the level areas.

Following a blast, a dozer graded the blasted rock, and the backhoes dug out the ditch. Western used Link-Belt LS 78 ¾-yd. backhoes for this, and

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

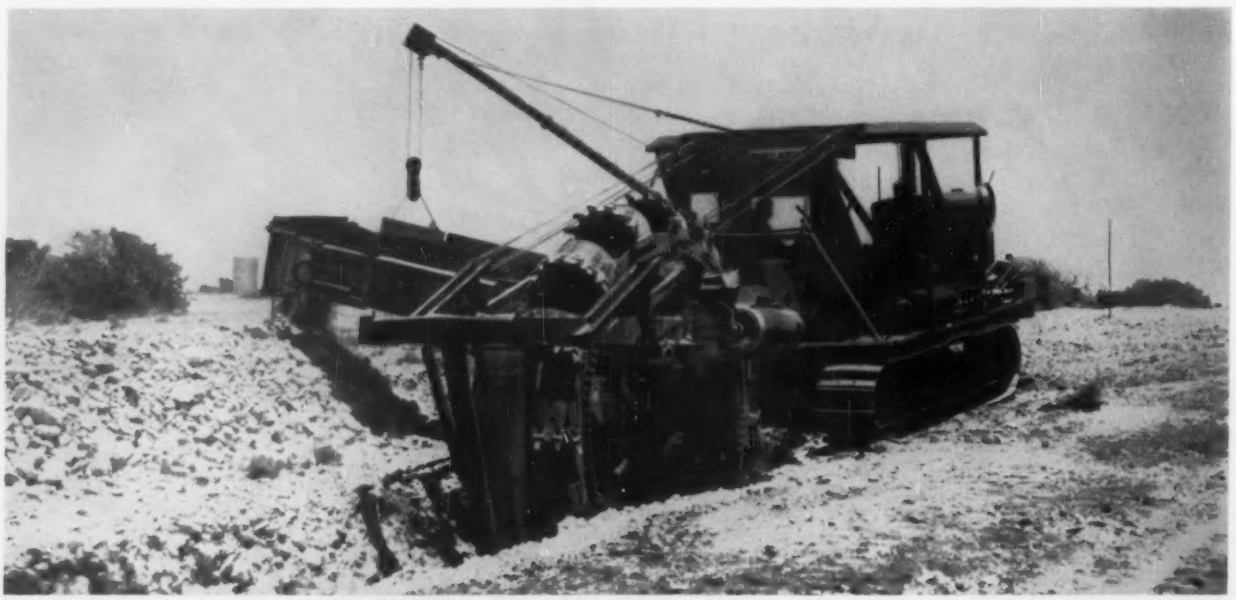
CAP-AND-FUSE SHOT: The ditch in the foreground has been loaded, and approximately 175 holes will be shot on the next lighting. Loading plan used resulted in an average explosives loading ratio of 1½ lb. to the linear foot of ditch blasted.

now and then reripped a little with the Kelly. Rock encountered was Edwards limestone and caliche rock on about 40% of the ditch. The average advance of the ditch was around 6,000 ft. daily, although on a few days when little blasting was required the crews pushed the ditch to an advance as high as 12,000 ft.

Two 30-cu. yd. TS 18 special Euclid scrapers provided material for the pipe padding from pits El Paso had staked.

The Lewis Montgomery Trucking Company of Odessa, Texas, strung the pipe under contract to El Paso. Pipe was bent to the contour of the ditch with a Crutcher-Rolfs-Cummings machine pulled by a Caterpillar D7. The pipe was laid with a D7 side boom, welded with 200-ampere Lincoln twin-arc welders on a sled pulled by an International TD 18. A Crutcher-Rolfs-Cummings cleaning machine cradled on a side boom of an Allis-Chalmers HD 16 cleaned and primed the pipe. Another HD 16 cradled a CRC coating and wrapping machine for that purpose, and four Cat D7 side booms lowered the pipe into the ditch.

A crew bored under all state and U. S. highways, and later came back and filled in all roads which were dug out, using seven Bucyrus-Erie A 22 clamshell buckets. A D7 dozer padded the top of the pipe with 6 in. of soil, and a D8 dozer did the back filling.



DIGGING IN BLASTED ROCK: A Cleveland 320 ditcher makes good progress following a shot which provided excellent breakage for easy handling. Rock encountered was Edwards limestone and caliche.

RUGGED TERRAIN: It was necessary to winch all equipment up the canyon wall because of the rugged terrain. The padding soil along the side of the ditch has been placed, and fragmentation obtained by the blast was good.

Equipment used on the job consisted of ten D7 Cat side booms, three Allis-Chalmers HD 16 side booms, two Cleveland 320 ditchers, one Kelly ripper, six Link-Belt LS 78 ¾-yd. backhoes, one Bucyrus-Erie 22 ¾-yd. backhoe, one Crutcher-Rolfs-Cummings cleaning and priming machine, one CRC coating and wrapping machine, five asphalt kettles, sixteen Lincoln 200 welding machines, two D7 twin-arc Tak rigs, and one 12 Cat maintainer.

Key Personnel

The project, under the direction of Western's Vice President C. L. "Chuck" Siewert, was staffed by Clint R. Schell, spread superintendent; Billy W. Schell, assistant spread superintendent; James Gray, office manager; D. B. Beaver, ditch foreman; W. E. Dodge, bending engineer; G. I. Peavler, pipe foreman; E. V. Enis, welding foreman; Henry Kays, coating foreman; D. F. McLain, lowering-in foreman; and Early Hensley, cleanup foreman. Western Pipe Line is headed by Gary Morrison, president, and Allan Shivers, chairman of the board. Offices are in Austin.

El Paso's inspectors were Herman Roethmeyer, chief inspector; K. W. Hummer, spread inspector; J. M. Robinson, ditch inspector; Cecil Warren, welding inspector; John R. Stephens, coating inspector; and John Collins, lowering-in and cleanup inspector.

BY REQUEST—IN CONCISE FORM IN CLEAR, NONTECHNICAL LANGUAGE

BLASTING VIBRATION

ITS ESTIMATION, COMPARISON & ANALYSIS

$1.00 POSTPAID

Response of Recording Instruments • Development of Measuring Instruments • Instrumental Comparisons • Human Estimates • Differences in Observations of Intensities • Vibration Facts Overlooked • Table of Common Vibration Intensities • Distribution of Explosive Energy • Effect of Repeated Vibrations of Minute Amplitude • Persistence of Internal Vibration • Settlement of Foundations • The Decay of Vibration Due to Distance

HAROLD H. WHITE

Consulting Engineer

2831 East 14th Street, Joplin, Missouri

INFORMATIVE BULLETINS FREE

[ ] Hercules Blasting Machines

[ ] Blasting Vibrations' Effects

[ ] Vibrations from Construction Blasting

[ ] Hercules Explosives, Blasting Agents, and Blasting Supplies

[ ] Hercules Vibrocap® SR for Seismograph Firing Circuits

[ ] Hercules No Vent® Short-Period Delay Electric Blasting Caps

[ ] Whatever You Need in an Electric Blasting Cap, Hercules Has It

Check the ones you want, clip and mail to:

HERCULES POWDER COMPANY

INCORPORATED

HERCULES TOWER • 910 MARKET STREET

WILMINGTON 99, DELAWARE

A Typical Day with a Hercules Representative

AN EARLY START enables Bob Shiel, Hercules technical serviceman, to observe step-by-step blasting procedures at his customer's mine.

CLOSE CONTACT between Bob and the mine superintendent eliminates most blasting troubles, and increases the operating economy of the mine.

UNDERGROUND with the tools of the trade, Bob examines some of the cars of blasted material to determine the effectiveness of the explosive charges.

BLASTING-PROCEDURE observation is a part of Bob's work. It takes the guesswork out of his job, and enables him to specify the proper explosives.

SHOP TALK helps find out if the remedy he's suggested has cured this mine's troubles. Bob's background gives him the insight necessary to make intelligent recommendations.

CHECKING and rechecking all the recommendations he has made gives Bob the satisfaction of knowing that he has been of assistance in solving his customer's blasting troubles.

Around the nation—around the clock

THERE'S ALWAYS A HERCULES MAN READY TO HELP YOU

Bob Shiel, E.M., Ohio State, is just one of the many specially trained Hercules men serving the explosives-consuming industries. For years Hercules has employed men with engineering training to sell and service its explosives throughout the United States and in many foreign lands. Our experience has proved that men with engineering training can meet their customers on common ground. They speak the same language, for most of the men who direct explosives-consuming work are technically trained.

When a young engineer starts his training as an explosives sales engineer with Hercules, he begins a period of orientation. He is then sent to our explosives plants and laboratories for thorough groundwork in products and processes. Upon completion of this indoctrination, he visits various sections of the country where he learns how explosives are used in underground and open-pit mines, rock quarries, heavy-construction jobs, and seismic exploration.

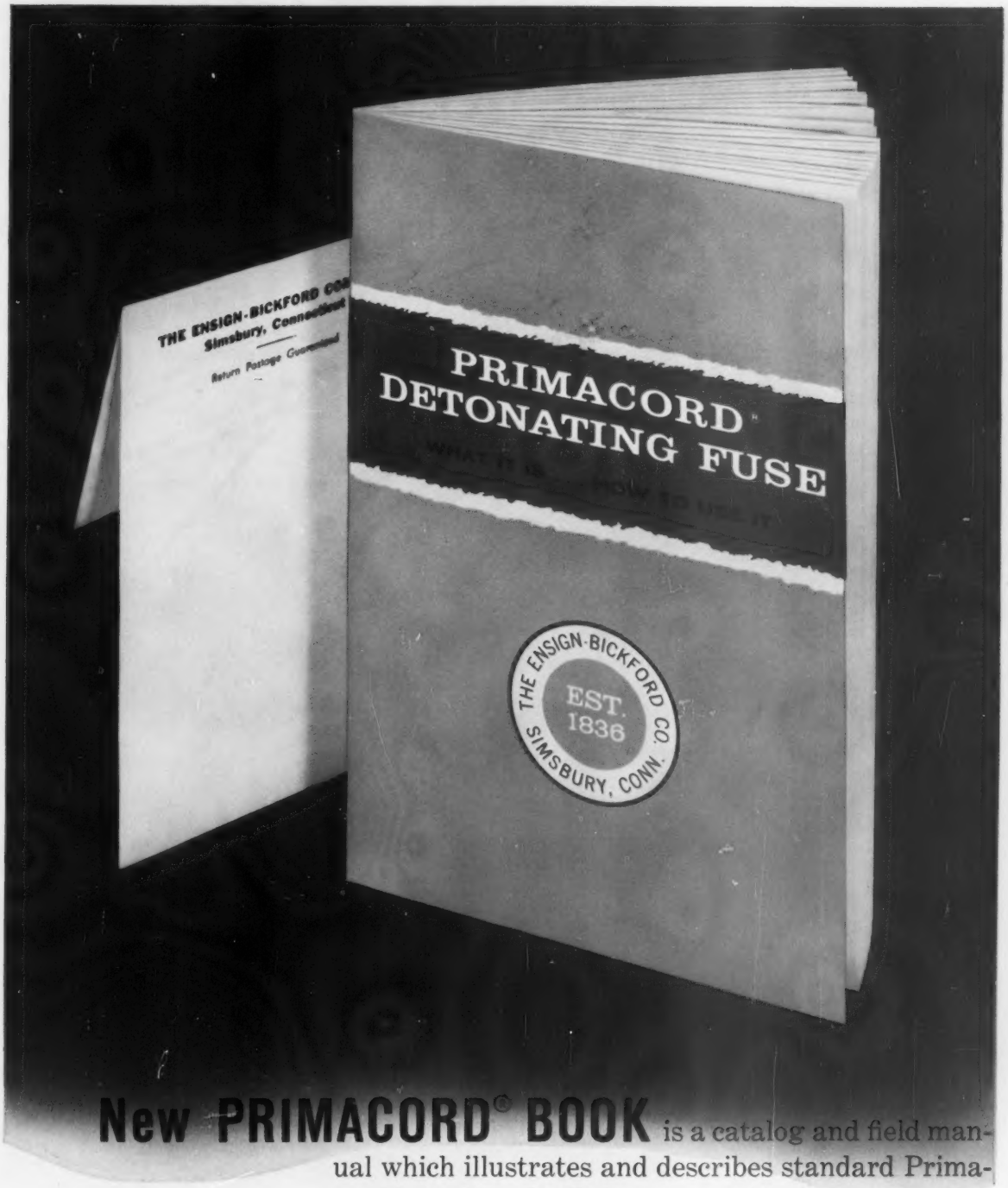
The cornerstone of Hercules Explosives Department is based on men who have the know-how to handle blasting problems quickly, efficiently, economically. To take advantage of this specialized service, call or write.

HERCULES

Explosives Department
HERCULES POWDER COMPANY
INCORPORATED
Hercules Tower
910 Market Street
Wilmington 99, Delaware

XR-60-2

BIRMINGHAM, ALABAMA • CHICAGO, ILLINOIS • DULUTH, MINNESOTA • JOPLIN, MISSOURI • LOS ANGELES, CALIFORNIA • NEW YORK, NEW YORK
PITTSBURGH, PENNSYLVANIA • SALT LAKE CITY, UTAH • SAN FRANCISCO, CALIFORNIA



New PRIMACORD© BOOK is a catalog and field manual which illustrates and describes standard Primacord brands and tells how to use this detonating fuse to obtain better blasting with greater safety and profit—in mining, quarrying and construction work.

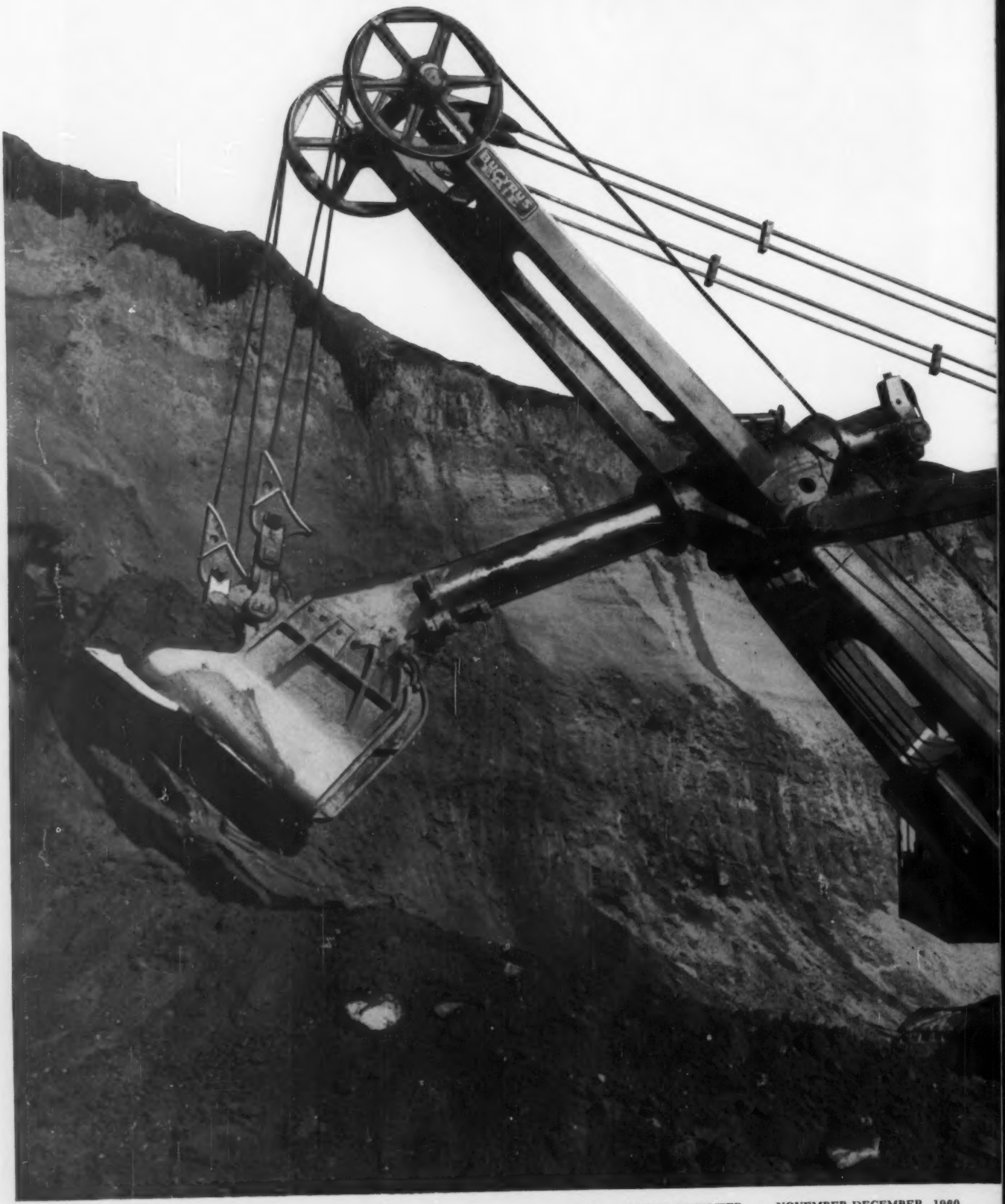
Ask your explosives supplier for a free copy or write to Sales Department

THE ENSIGN-BICKFORD COMPANY

Simsbury, Connecticut Since 1836

P-6

going big? .



. go electric

with Bucyrus-Erie!

...announcing NEW electric control that wipes slate clean on "can'ts" of old-style machines!

NEW CONTROL — only on Bucyrus-Erie electric excavators, a modern control that sets a new standard of electric operation to help you make every assignment more profitable!

SPECIFICALLY, with this new Bucyrus-Erie control there's no excessive heat loss, even in stall conditions. In tough digging, torque is increased, speed reduced — you move on through the digging cycle!

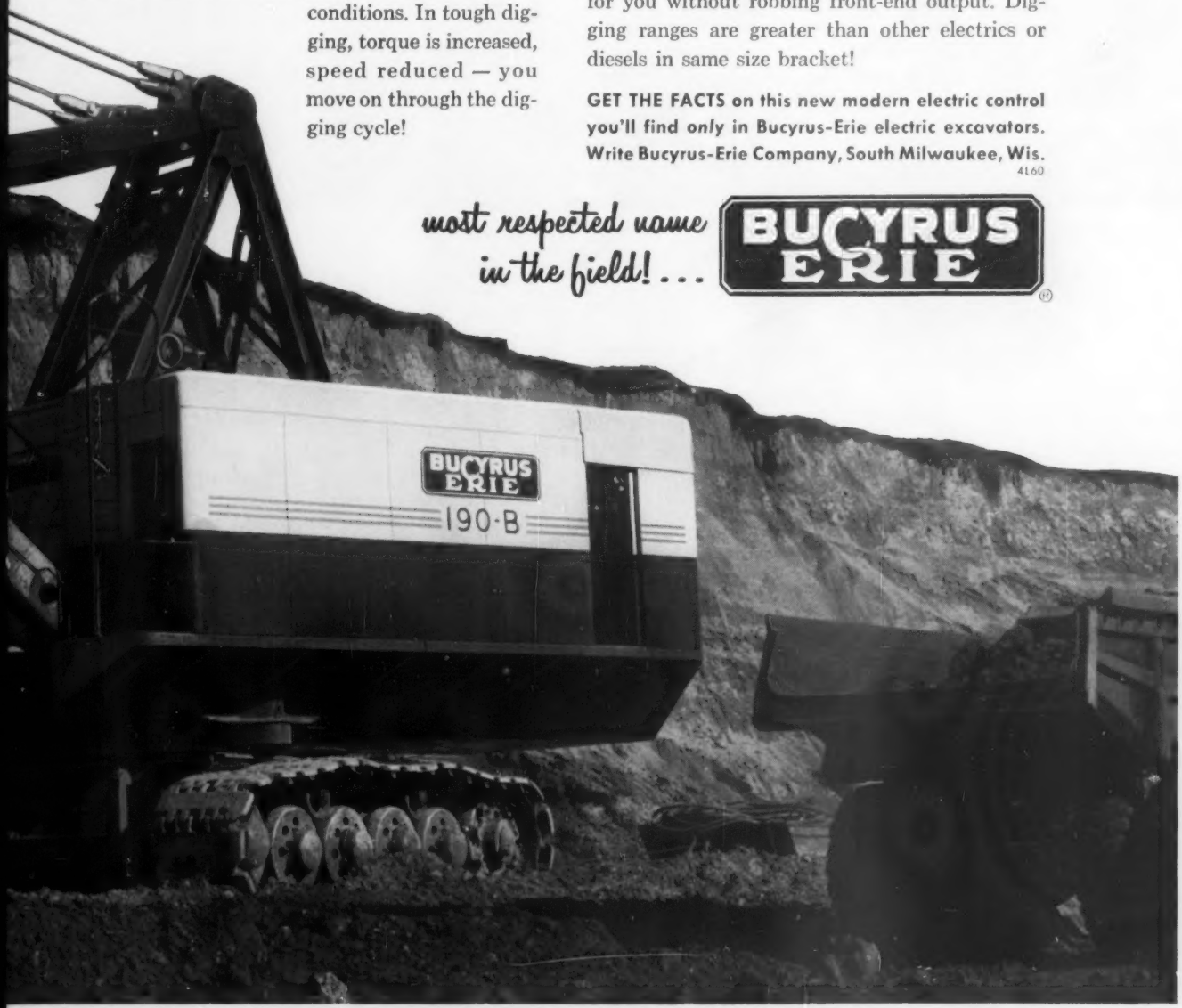
GRADUAL TURNS can be made on hard quarry floors in either direction without forward-reverse jockeying so often damaging to crawlers.

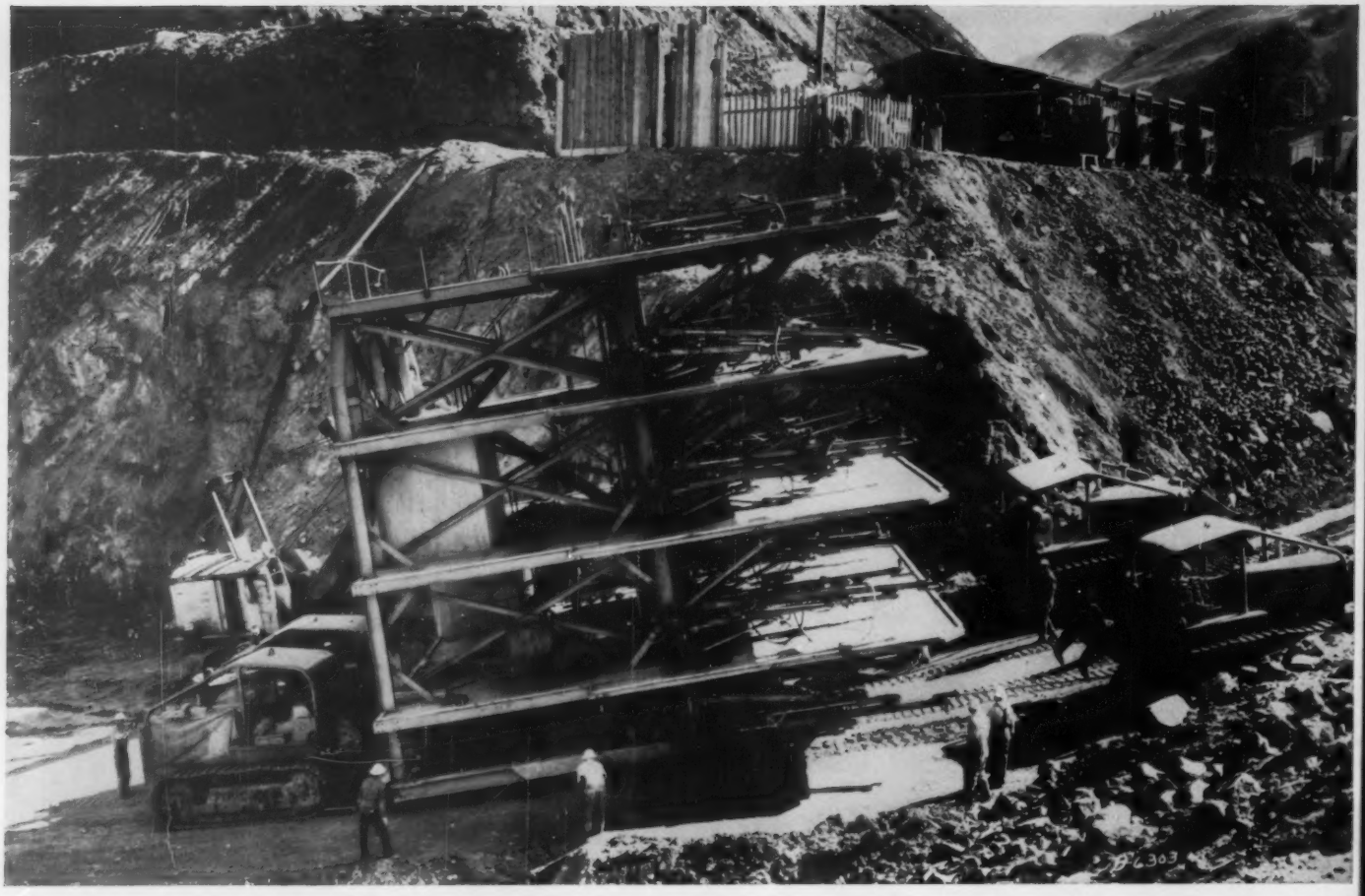
There are **NO OPERATING CLUTCHES** with this new Bucyrus-Erie control. Each function has its own power source. Power is used for that specific function — no other. You get full power up and power down for hoisting and lowering.

CROWD MACHINERY is mounted on the revolving frame, not on the boom. Weight works for you without robbing front-end output. Digging ranges are greater than other electrics or diesels in same size bracket!

GET THE FACTS on this new modern electric control you'll find *only* in Bucyrus-Erie electric excavators. Write Bucyrus-Erie Company, South Milwaukee, Wis.
4160

most respected name in the field!... BUCYRUS ERIE





World's biggest Hydra-Boom jumbo drives OXBOW TUNNELS

19 Hydra-Boom mounted I-R drifters on five-level air-driven jumbo, drill twin 42-ft bores for 200,000 kw hydro station

Shown above being moved up to the working area with an assist from four tractors, is the largest tunnel jumbo ever built—taller than a four story building and carrying the concentrated "fire power" of 19 Ingersoll-Rand D-45 drifters on 10-ft chain feeds with I-R Hydra-Boom mountings. Designed and built by Morrison-Knudsen Company, Inc., this huge jumbo was used to drive the twin 42-ft horseshoe power tunnels that will supply Idaho Power Company's 200,000-kw hydro-electric station on the Oxbow bend of the Snake River.

The Hydra-Boom mountings permit rapid hydraulic positioning of all drills from convenient centralized controls at each drilling station. Drilling 2½" holes 10 ft deep with modified Vee pattern in the hard, chunky columnar basalt of the area, the jumbo was moved alternately from one bore to the other—drilling in one while the other was blasted and mucked. The crawler-mounted jumbo is self-propelled in the working area by 25-hp I-R air motors.

Air power for the tunnel jumbo was supplied by a bank of six skid-mounted I-R electric-driven XLE compressors with a total capacity of about 8000 cfm at 100 psig—shown at upper right in the photo above.

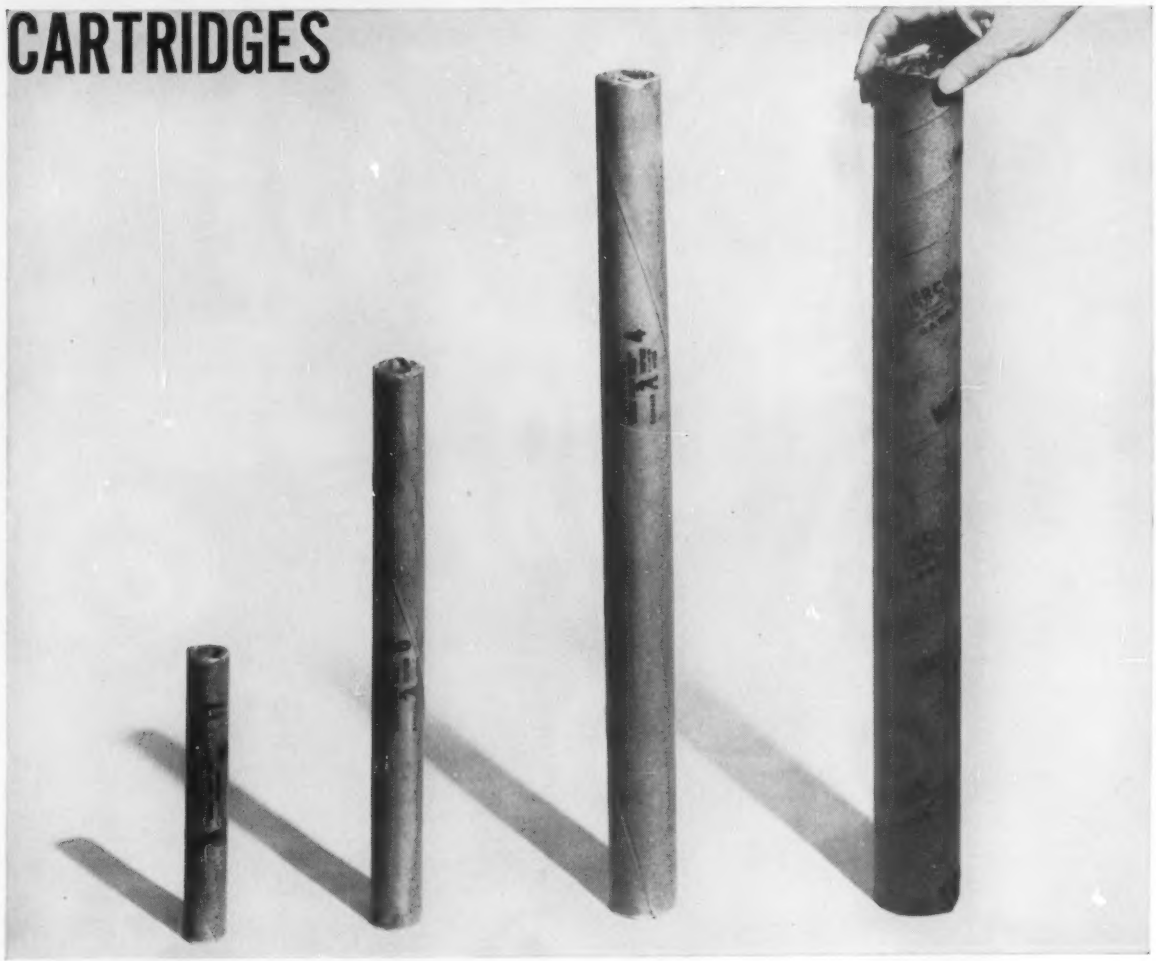
Whenever you want fast, effortless drill positioning on any job, be sure to check the advantages of I-R Hydra-Boom mountings. Your Ingersoll-Rand engineer will be glad to give you complete information.

Ingersoll-Rand

102A5 11 Broadway, New York 4, N.Y.

A CONSTANT STANDARD OF QUALITY IN EVERYTHING YOU NEED FOR DRILLING ROCK.

HERCOL®—A LOW-COST EXPLOSIVE— NOW AVAILABLE IN SMALL-DIAMETER CARTRIDGES



The Hercol series of low-cost, cap-sensitive, high-ammonia-content explosives are now available in cartridges of small diameters and standard lengths, as well as in the larger diameters and special packings.

The ability of Hercol to produce excellent fragmentation, its water resistance, Class 1 fumes, and high cartridge count—plus its low cost—have already been proved to the economy-minded quarry and open-pit operator.

Now that Hercol is manufactured in the smaller diameters, with Class 1 fumes, these same economies are available to the underground operator.

Contact the Hercules sales office nearest you or ask your Hercules representative for more detailed information on how Hercol can reduce blasting costs for you, too.

Properties of Hercol

	Hercol	Hercol 2	Hercol 4	Hercol 6
Fumes	Good	Good	Good	Good
Cartridge count—1¼ by 8-in. cartridges per 50 lb.	130	120	140	165
Cartridge diameter, in.	4 to 8½	1 to 3½	1 to 3½	1 to 3½
Weight strength, %	70	68	68	68
Cartridge strength, %	48	50	34	19
Water resistance	Fair	Good	Fair	Fair

A special grade of Hercol is formulated for seismic "pattern shooting" when the drill-holes are relatively dry.

Explosives Department

HERCULES POWDER COMPANY

INCORPORATED

Hercules Tower, 910 Market Street, Wilmington 99, Delaware

XR60-1

BIRMINGHAM · CHICAGO · DULUTH · JOPLIN · LOS ANGELES · NEW YORK · PITTSBURGH · SALT LAKE CITY · SAN FRANCISCO

THERE'S NO EASIER DRILL TO RUN THAN A REICHdrill!

T-750 truck-mounted REICHdrill. Hole size to 12"; down pressure 45,000 lbs. Other models available, truck or crawler mounted, with hole size to 16 inches, down pressure to 90,000 pounds

This smooth operating, all-hydraulic rotary rig is helping REICHdrillers set higher footage records.

In blast holing, prospecting and coring, there's no easier drill to run than a REICHdrill. And the key to money making drilling records is a simplified *control "console"*. From it, every move required by the driller . . . every decision he makes...is converted smoothly, instantly, by the all-hydraulic system, into positive, time-saving performance.

Hydraulic drive to drill stem eliminates power loss . . . transmission troubles . . . kelly and rotary table.

Vari-speed Hydraulic Drill Control gives the operator the right combination of rotary speed and feed pressure for every formation...leveling jacks, mast raising cylinder and barrel loader are hydraulic too!

Other features: fast, easy set-ups; masts incline for angle drilling; CP heavy-duty compressors; CP Air-Blast Bits for extra footage in toughest formations. *You get more from your rotary when it's a* REICH*drill!*

For further information write:

REICHdrill

FRANKLIN (VENANGO COUNTY), PENN.

Division: CHICAGO PNEUMATIC TOOL CO.

Positioned at control "console", REICHdriller has every rig maneuver in sight . . . every rig control in reach.